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# CHARACTERISTICS OF THE ARC IN TUNGSTEN INERT GAS & METALLIC INERT GAS WELDING: AN ANNOTATED BIBLIOGRAPHY

SPECIAL BIBLIOGRAPHY
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# CHARACTERISTICS OF THE ARC IN TUNGSTEN INERT GAS & METALLIC INERT GAS WELDING: AN ANNOTATED BIBLIOGRAPHY

Compiled by
S. J. BUGINAS

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Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

## ABSTRACT

The references in this bibliography were selected to assist researchers working with Tig and Mig welding of thick plates. The search was centered around arc characteristics and power sources, although related references were included. Process descriptions were not generally included. A 10-year period, beginning in 1952, was covered.

Search completed July 1962.

Availability notices and procurement instructions following the citations are direct quotations of such instructions appearing in the source material announcing that report. The compiler is well aware that many of these agencies' names, addresses and office codes will have changed; however, no attempt has been made to update each of these notices individually.

In citing classified reports, (SECRET TITLE) or (CONFIDENTIAL TITLE) as appropriate, has been used when that classification of the title was indicated on the report. (UNVERIFIED TITLE) has been used when the report was not available to the compiler and it was impossible to verify the report's title and the title's security level.

Classification of classified reports is indicated by abbreviation in upper right top line of bibliographic entry. The classification of the report is given in full, e.g., SECRET REPORT, at the conclusion of the bibliographic data for that report entry.

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This selective bibliography has been prepared in response to a specific request and is confined to the limits of that request. No claim is made that this is an exhaustive or critical compilation. The inclusion of any reference to material is not to be construed as an endorsement of the information contained in that material.

1. Allen, G.

Aluminum welding using inert plug-nitrogen-gas metal-arc process. WELDING J. v. 38, n. 3 p. 132s-41s. 3 Mar 1959.

A special technique is developed to reduce the cost of aluminum welding and to make it less dependent upon the supply of inert gas.

2. Arc welding of aluminum. ALUMINUM DEVELOPMENT ASSOC. INFORMATION BULL. n. 19, 92p. Dec 1955.

Discusses the welding arc; weldability, inert gas shielded arc welding and carbon arc welding.

3. Arnaud, R.

Welding arc in an argon atmosphere using a non-consumable electrode. BULL. SOC. FRANC. ELEC. (SER. 7) v. 2, p. 626-32, Nov 1962. (IN FRENCH)

D. C. straight polarity and reverse polarity, and a. c. inert-gas shielded arc welding theory are reviewed. Methods of d. c. suppression and arc stabilization in a. c. welding have been investigated by high-speed photography and with a mirror oscillograph.

4. Bengtsson, G.

Inert-gas tungsten arc welding of aluminum and its alloys, ASEA J. v. 34, n. 8-9, p. 154-9, 1961.

Discusses the origin and influence of the d-c component when employing inert gas tungsten arc welding with argon.

5. Bergmann, E.

High-frequency stabilization of the welding arc.

ELECTROTECH. Z. (ETZ) v. 72, p. 679-82

Dec 1, 1951, (In German)

Ionization of the air-gap between the electrode and the workpiece by superimposing a h.f. current allows the arc to be struck without physical contact being established. Arc breakdown and rectification are eliminated, particularly in the welding of light alloys. Several spark gap oscillator circuits are discussed. Oscillograms show their output to consist of frequent, heavily dampened h.f. impulses of approximately 1 Mc/s at 300 V r.m.s.

6. Brain, A. G.

$CO_2$ welding of sheet materials,

BRIT. WELDING J. v. 7, n. 7, p 463-71

July 1960.

Describes difficulties involved in applying $CO_2$-shielded metal arc processes to welding steel sheet. Study of $CO_2$ arc characteristics has enabled satisfactory welding conditions to be established.

7. Brillie, J.

Le soudage a l'arc Nertalic-Aircomatic,

REV. DE LA SOUDURE (LASTIJDSCHIFT)

v. 10, n. 1, p. 22-32, p954; also in REV.

L'AIR LIQUIDE v. 2, n. 5, p. 3-10, 1954.

(In French)

Arc characteristics were studied in the Nertalic-Aircomatic arc welding process.

8. Brillie, J.

Studies on Argonarc welding. SOUDURE ET TECHNIQUES

CONNEXES, v. 8, n. 7-8, p. 195-204, July-Aug 1954

(In French)

9. Brown, Paul E, and Adams, C.M., Jr.

Massachusetts Inst. of Tech., Cambridge.

FUSION-ZONE STRUCTURES AND PROPERTIES IN ALUMINUM ALLOYS. LABORATORY INVESTIGATION INCLUDES THE EFFECTS OF STRUCTURE AND COMPOSITION ON THE PROPERTIES OF ARC DEPOSITS, AS WELL AS THE EFFECT OF WELDING PROCEDURE ON STRUCTURE, 5p. 1960.

Incl. illus. tables. (In cooperation with the Aluminum Co. of America) (Sponsored by Office of Ordnance Research), (OOR rept. no. 2344.1)

Unclassified report.

Paper presented at AWS National Fall Meeting held in Pittsburgh, Pa., Sep 26-29, 1960.

Reprint from Welding Jnl Research Supplement, Dec 1960. (Copies not supplied by ASTIA)

Microstructural details of 2014 aluminum alloy arc deposits have been quantitatively related to solidification rate as determined by arc-energy input. The results conform to the theory of dendritic solidification based on mass transport in the liquid phase. Because of their very high rates of solidification (far greater than in any casting process), arc deposits exhibit very fine dendrite textures leading to unique mechanical properties and rapid response to heat treatment.

10. Browne, T.E. Jr.

Electric arc as circuit element, ELECTROCHEM SOC. J. v. 102, n 1, p. 27-37, 1 Jan 1955.

Discusses static and dynamic voltage current characteristics, with emphasis on high current arcs. Typical arc behavior in d-c and a-c circuits is described. The nature and use of mathematical models in this study is presented. Bibliography.

11. Cameron, J. M. and Baeslack, A. J.
Straight-polarity, inert-gas process for welding mild steel. WELDING J. v. 35, n. 5, p. 445-9. May 1956.

Arc stabilization and other arc characteristics are described. Characteristics of the welding power supply and electrode feeding mechanism are presented.

12. Campbell, J.
Control of process variables - key to successful welding of foil. WELDING J. v. 38, n. 12, p. 1182-91. Dec 1959.

Effects of variation of arc current, travel speed and arc length on fusion and the influence of these parameters on joint efficiency are included.

13. Clark, E. J.
Welded tubular-bucketed turbine wheel, WELDING J. v. 40, n. 5, p. 522-8, May 1961.

Description of techniques, equipment, and post heat treatment used in Tig welding buckets formed from 0.010-in. thin wall tubing to the turbine wheel.

14. Cobine, J. D., and Burger, E. E.
Analysis of electrode phenomena in high-current arc. J. APPL. PHYS., v. 26 n. 7, p. 895-900, July 1955.

In this study of the short time arc it is shown that input power density to the anode spot is in the range $5 \times 10^4$ to $1 \times 10^6$ watts/cm$^2$. To first order approximation, all this power can be carried off by evaporation.

15. Cobine, J.D. and Gallagher, C.J.

New electrodes for stabilizing inert-gas welding arcs. AIEE Trans., v. 70 Part I, p. 804-806, 1955.

W electrodes eliminate some of the difficulties of arc ignition and lack of stability which occur during inert gas welding. Volt ampere characteristics of arcs, in or/on are shown for these types of electrodes.

16. Conn, W. M.

An instability of the molten electrode in arc welding. WELDING J., v. 41, n. 4., p. 171s-174s, 1962.

A photographic study of the role of unduloids during filler metal transfer from electrodes is reported.

17. Conn, W. M.

Die Technische Physik der Lichtbogenschwissung einschliesslich der Schweissmittel, (v. 13 of (TECHNISCHE PHYSIK IN EINZELDARSTELLUNG") Berlin, Springer Verlag, 386p. 1959.

The application of physics to arc welding.

18. Correy, T. B.

High quality fusion welding of aluminum, v. 16, n. 5-6, 7-8, 9-10, June, p. 8-12; Aug., p. 12-14, 16, 22, 24-6; Oct., p. 8-13, 1958.

Arc phenomena, arc starting, and rectification in an a-c arc are discussed. Transformer voltage and current characteristics, current controls and inert arc welding transformer characteristics are included. A description of the Tungsten electrodes.is provided. 25 refs.

19. Correy, T. B.

Waveshape effect on alloying and arc stability

of a.c. tungsten inert-arc welding. AIEE,

PART II. APPLICATIONS AND INDUSTRY

v. 80, p. 171-183, Sept. 1961.

Improvement of fusion weld alloying with square-type current waves in the closure weld of AlSi-bonded Al-clad uranium-metal fuel elements is established. The more desirable characteristics for the welding power supply are a balanced current waveshape, and an open-circuit potential of 130 volts for argon-helium mixtures of up to 3 argon, 9 helium by volume.

20. Davis, E., and Terry, C. A.

Nitrogen-arc welding of copper.

BRIT WELDING J. v. 1, n. 2, p. 53-64,

(discussion) n. 11, p. 508-11, Nov. Feb 1954.

The use of nitrogen instead of argon was investigated. Factors influencing arc stability and tungsten transfer across the arc were studied. Reasons for the greater power of nitrogen-shielded as compared with an argon arc are presented.

21. Dixon, A.

A double-taper tungsten-arc welding control.

WELDING J., v. 40, n. 10, p. 1029-1034, 1961.

Electropneumatic taper controls were devised to eliminate weld craters and to improve weld appearance.

22. Dyurgerov, N. G., et al

Effect of circuit inductivity on the carbon

dioxide-shielded arc welding process.

SVAROCHNOE PROIZVODSTVO, p. 15-18, April 1960.

Inductive resistivity in an arc created by a choke coil reduces splashing of the metal, eliminates weld cleaning and increases process stability.

23. Dzimianski, J. W., and Jones, T. B.

Characteristics of high-current argon arc with various electrode materials. AIEE - TRANS., v. 74, pt 1 (Communications & Electronics) n. 16, p. 665-9 (discussion) 669-70, Jan 1955.

Properties of a high current d-c arc in argon at atmospheric pressure, at currents of 25 to 100 amp were studied. Spectroscopic observations were made on the arc. Data for voltage-current and voltage-arc length characteristics are presented.

24. Edels, H.

Properties and theory of the electric arc. A review of progress. INST. OF ELECTRICAL ENGINEERS, PROC., PART A, POWER ENGINEERING, v. 108, p. 55-69, 1961.

Includes a review of the welding arc, bibliography with 123 refs.

25. Erdmann-Jesnitzer, F., et al

Effect of high current frequencies in arc welding of steel. SCHWEISSTECHNIK, v. 15, p. 145-152 Dec 1961. (In German)

Includes a study of arc stability. Welding was done at 50-900cps frequency, using a generator with permanent magnets.

26. Erdmann-Jesnetzer, F., et al

Observations on the effects of magnetic fields in arc welding. WERKSTATT UND BETRIEB, v. 94, n. 8, p. 506-508, 1961. (In German)

Explanations of observed effects on current intensity, voltage, arc length, fusion capacity, and arc temperature are not yet possible.

27. Fenton, E. A.

Recommended practices for gas shielded-arc welding of aluminum and aluminum alloy pipe. AMERICAN WELDING SOCIETY PUBLICATION, n. D10.7-60, 25p, 1960.

Includes machine settings and variables. Contains information on tungsten arc and metal arc welding.

28. Finkelnburg, W.

Experiments on the mechanism of high temperature arcs at low burning voltage. APPLIED SCIENTIFIC RESEARCH (The Hague) v. 5, n. 1-4, p. 201-204, 1955. (In German)

Discussion of burning voltage and anode and cathode falls as functions of current (0-200A) and pressure (0-10atm) at a current of 200 A for arcs of 6 and 10 mm respectively in argon. Includes graphs.

29. Finkelnburg, W.

The physical mechanisms of low- and high-current arcs and their relation to the welding arc. AIEE TRANS., v. 70, 800-3 (Pt 1 1951)

29. cont'd)

The paper gives an account of the physics of arc discharges, with special reference to technical problems, e.g. electrode processes involved in arc welding.

30. Gibbs, E. F.

Fundamental study of tungsten arc.

METAL PROGR., v. 78, n. 1, p. 84-92,

July 1960.

A report of work done at Boeing. Includes information on arc performance, arc voltage and length, voltage distribution, and electrode configurations.

31. Gillette, R.H. and Breymeier, R.T.

Some research techniques for studying arcs

in inert gases. WELDING J. v. 30

n. 3, p. 146s-152s, 1951.

Methods include probe and heat transfer measurements, and slow motion photography.

32. Ginn, J. E.

Electrical and metallurgical factors influencing

welding arc stability. WELDING J., v. 40,

n. 9, p. 942-946, 1961.

Studies were conducted to determine the primary causes of arc instability and methods of forestalling its occurrence in welding stainless steel and low carbon alloy steel. The three major factors that affect arc operation are material properties, tooling and field forces.

33. Greene, W.J.

Analysis of Transfer ın Gas-Shielded Welding Arcs.

AIEE – TRANS. v. 79, Pt. 2 (Applications & Industry)

n 49, p. 194-202 (discussion) 202-3, July 1960.

Presents a theory of metallic transfer.

34. Gufan, R. M., et al

Certain features of welding with carbon dioxide shielding on alternating current. WELDING PRODUCTION (English translation of SVARO-CHONE PROIZVODSTVO) n. 1, p. 69-74, Jan 1960.

Indications are that a. c. automatic $CO_2$ welding is possible in principle. Arc re-ignition, occurrence of intense spatter, and the presence of a direct component in the welding current and voltage complicate welding. Consistent reignition of the arc can be brought about by connecting an oscillator in the circuit.

34.1 Hazlett, T. B. and Gordon, G. M.

Studies of welding arcs using various atmospheres and power supplies. WELDING J. v. 36, n. 8 p. 882s-6s, Aug 1957.

Contains the results of a preliminary survey to study more completely the variables connected with consumable electrode gas shielded welding of steel. With helium and argon plus 5% oxygen, there was no significant difference in arc characteristics, bead shape, or penetration found between using a modified motor generator set or rectified a-c. For pure argon significant differences in arc action and bead shape were observed.

34.2 Helmbrecht, W. H. and Hackman, R. L.

Effect of power supply characteristics on sigma welding. WELDING J. v. 33, p. 6, p. 531-6. June 1954.

Discusses the operating characteristics of the welding power supply; the welding operation and auxiliary control equipment was simplified by the use of constant potential type power supplies with sigma welding.

35. Hirschmann, F.

D. C. plants for argon-arc welding.

WELDING & METAL FABRICATION, v. 21

n. 6, p. 201-4, June 1953.

An a-c/d-c motor generator was built for use in research laboratories. The advantages of rectifiers, the circuit diagram for a rectifier and a "silent arc" are pointed out as notable feature of rectifier plant.

36. Holländer, E. F.

The application of the thermodynamics of irreversible

processes to welding arcs. CZECH. J. PHYS.,

v. 9, n. 2, p. 229-236, 1959. (In English)

A thermodynamic equation is derived for the self-regulation of a welding arc.

37. Huff, H. A., Jr.

Some practical considerations in application of

tungsten arc welding. WELDING J. v. 33, n 9,

p. 868-74, Sept 1954.

38. Hull, W. G. and Needham, J. C.

The self adjusting arc and controlled arc welding

processes. REP. BRIT. ELECT. RES. ASSOC.,

REF. Z/T93, 31 pp. (1953).

(See Needum & Hull, entry No. 69).

39. Jackson, C. E.

The science of arc welding. WELDING J.

v. 25, n. 4, (Part I), p. 129s-140s; (Part II) n. 5,

p. 177s-190s; (Part III), n. 6, p. 225s-230s, 1960.

Parts I and II discuss "what the arc is," and Part III discusses "what the arc does." A review with 80 refs.

40. Jackson, W. J.

A review of the theory and practice of inert-gas

shielded-arc welding. SHEET METAL INDUSTRIES,

v. 28, p. 1131-1136, 1951.

41. Jahn, R. E. and Gourd, L. M.

Assessment of gas-shielded $I^2Rt$ welding.

WELDING & METAL FABRICATION, v. 27,

n. 3, p. 92-101, March 1959.

The process is evaluated and the equipment needed is described.

42. Jones, T. B., <u>et al</u>

The electric arc in argon and helium.

APPLICATIONS AND INDUSTRY, p. 16-21,

March 1953.

A study of arc characteristics when welding with tungsten electrodes.

43. Joy, L,

Tig welding zinc alloys.

WELDING ENGR v. 40, n. 10, p. 47-8,

Oct 1955.

Good results were obtained in welding zinc die castings using a-c current with superimposed high frequency stabilization.

44. Kasprzhak G. M. and Alekin, L. E.

Problems in the theory of self-regulation in

welding with consumable electrodes.

ELEKTRICHESTVO, No. 5, 41-9, 1955.

(In Russian)

The mechanism of arc self-regulation in welding with a consumable metal electrode and with an independent rate of feed of the electrode wire is described. The concepts of amplification factors and time constants of the links and circuits of the system of self-regulation are introduced. Recommendations are made for improvements in the system. The practical value of the method is shown on an example and experimental data illustrate its accuracy. Analysis of the regulation process shows that is is not purely astatic, but is both a current and voltage regulating process. The effect of supply voltage variations on weld irregularities and of the transient processes on weld quality are investigated.

45. Keel, B.

Fresh light on phenomena in inert-gas shielded arc

welding with fusible electrodes. Z. für SCHWEISSTECHNIK,

no. 4, p. 86-89, April 1957. (In French and German)

Presents an analysis of the factors involved in electrode activation and the emissive potentials of several base metals. Author submits a theory that by the addition of activating agents the distribution of heat in the electric arc can be regulated.

46. Krasulin, Yu. L., and Sagalovich, V.V.

Inert gas arc welding of light-gauge stainless steel sheet with consumable electrode, using mixture of $CO_2$ and argon. WELDING PRODUCTION (English Translation of Svarochnoe Proizvodstvo) n. 9, p. 18-20, Sept 1960.

Stable fine-droplet metal transfer in arcs at a current density of 40 amp/mm$^2$ with the electrode negative, and 60 amp/mm$^2$ with the electrode positive were obtained.

47. Kuhn, W. E. (ed)

ARCS IN INERT ATMOSPHERES AND VACUUM. (Papers presented at The Symposium on Arcs in Inert Atmospheres and Vacuum of The Electrothermics and Metallurgy Division of The Electrochemical Society. San Francisco, California, April 30 and May 1, 1956) (Sponsored by The Electrochemical Society, Inc., New York, N.Y.) N. Y. Wiley, 188p. 1956.

Treats the area of arc technology concerned with the fundamentals and applications of high current arcs in inert atmospheres, vacua, and in vapors and gases produced by the evaporation of electrodes.

48. Lancaster, J. F.

Energy Distribution in argon-shielded welding arcs. BRIT. WELDING J. v. 1, p. 412-426, Sept 1954.

Anode and cathode heat losses are related to potential drops for d.c. shielded-arc welding.

49. Lee, T. H. and Greenwood, A.

Theory for the cathode mechanism in metal vapor arcs. J. APPL. PHYS. v. 32, n. 5, p. 916-927, 1961.

The authors show that in the cathode drop region of a metal vapor arc, there are four equations and two limiting conditions relating five dependent variables. The variables are the temperature of the cathode spot, the electric field at the cathode, the total current density, the current density carried by electrons and the radius of the spot. When these equations are combined, a current level is found below which no solution exists. It is proposed that this current corresponds to the point at which a vacuum arc extinguishes in an a. c. circuit.

50. Lesnewich, A.

Control of melting rate and metal transfer in gas-shielded metal-arc welding. Part 1-Control of electrode melting rate; Part 2-Control of metal transfer. WELDING J. v. 23, n. 8, p. 343s-353s; n. 9, p. 418s-425s, 1958

Heat for electrode melting is produced simultaneously by anode or cathode reactions. Only a small portion of the heat is received by radiation from the arc stream or weld crater. Arc length has a measurable effect on melting rate only in a very few welding applications.

51. Lesnewich, A.

Electrode activation for inert-gas-shielded metal arc welding. WELDING J. v. 34, p. 1167-1178, 1955.

Dilute thin coatings of alkali, alkaline earth and rare earth elements facilitate stable metal transfer.

52. Lesnewich, A. and Cushman, E.

Power supplies for gas-shielded metal-arc welding. WELDING J. v. 35, n. 7 p. 655-664, July 1956.

The best general purpose power source is a constant-voltage transformer-rectifier with automatic regulation for fluctuations in line voltage.

53. Lisser, J. and Kas, J.

New apparatus for the stabilization of a.c. welding arcs. SMIT MEDED., V. 13, n. 2 p. 66-77, April-June 1958. (In Dutch)

With certain a.c. arc welding processes, e.g. argon arc welding, arc re-ignition voltage may require high values for the open circuit voltage of the welding transformer. These values can be lowered by feeding a short-duration pulse having a peak voltage of about 200 v. at each instant that the a.c. arc is quenched. Adequate stabilization of the arc is obtained with welding currents up to 300 A.

54. Ludwig, H. C.

The measurement of temperature in welding arcs. ELECT. ENG. v. 79, n. 7, p. 565-569, 1960.

A recording spectrophotometer is used to measure the spectral intensity variation across the arc. The relative intensity of the chosen line is then used to determine the arc temperature.

55. Ludwig, H. C.

Metal transfer characteristics in gas-shielded arc welding. WELDING J. v. 36, n. 1, p. 23s-26s, 1957.

Contains an analysis of the kinematics of single bodies of transferring arc metal. The suggestion is made that the major force component causing metallic drop ejection from the electrode is electromagnetic action.

56. Mann, H.D. and Purkhiser, R. E.

Automatic inert-gas-shielded tungsten-arc welding of aluminum alloys. WELDING J. v. 36, n. 8, p. 790-797, 1957.

Alternating current was successfully used with existing equipment to weld aluminum alloys. Discusses characteristics of a.c. arcs and of welding machines. Recommendations were made for installing a high frequency inner arc welder.

57. Mantel, W.

Significance of the power supply for arc welding with inert gas protection. ELECTROWÄRME-TECH., 5, No. 11, 231-4, Nov 1954. (In German)

A. c. and d.c. welding with a tungsten electrode and d.c. welding with melting metal electrode are discussed separately. In a.c. welding, a primary consideration is the rectifier effect of the arc which must be counteracted by a battery, series resistors, or suitable filter connections. In Mig welding, a horizontal or even slightly rising voltage/current characteristic as produced by a compounded or over-compounded generator is successful.

58. Mc Elrath, T.

Inert-gas consumable-electrode welding of thin material. WELDING J. v. 38, n. 1 p. 28-33, Jan 1959.

New short arc techniques, suitable power supplies and wire feeding equipment have been developed which make it possible to extend the inert gas consumable electrode process to the welding of common metals in the range of thicknesses from 0.015 to 1/8 in. at high production speeds.

59. Mc Fee, W. E.

A review of inert arc welding (stainless steel). INDUSTRY AND WELDING, v. 30, p. 54-59, March 1957.

60. McFall, S. E.

Inert-Gas Shielded Metal-Arc Spot Welding of Aluminum. WELDING J. v. 39, n. 12 p. 1230-6, Dec 1960.

An investigation of commercial equipment was made in order to determine which equipment had the best compromise of advantages and disadvantages.

61. McGregor, W. P.

Inert-gas tungsten-arc spot-welding for missile assemblies. MACHINERY (LONDON), v. 98 p. 886-888, April 19, 1961.

Weld quality is influenced by current density, arc length, number of cycles, gas coverage and flow, type of electrode, etc.

62. McLean, C. A.

Inert-gas shielded tungsten-arc spot welding. WELDING J. v. 34, n. 7, p. 648-56, July 1955.

Investigation of variables affecting welding, such as amperage, shielding gas, electrode and arc length.

63. Milner, D. R.

Arc striking with argon-hydrogen mixtures in argon-arc process. BRIT. WELDING J. v. 2, n. 6, p. 246, June 1955.

Describes a cheap and simple method of arc striking which eliminates troubles encountered with commercial equipment when the $H_2$ addition was more than a few per cent of the total gas flow.

64. Milner, D.R., Salter, G.R. and Wilkinson, J.B.

Arc characteristics and their significance in welding, BRIT. WELD. J., v. 7, n. 2, p. 73-88, Feb, 1960.

A survey of arc physics relating to chemico-metallurgical reactions occurring between the arc atmosphere and the weld metal, heat transfer from the arc, and metal transfer in consumable electrode welding was made.

65. Moneyron, M.

High-frequency apparatus for starting and maintaining an arc. SOUDURE ET TECHNIQUES CONNEXES, v. 5, p. 217-221, Sept/Oct 1951. (In French)

Describes method to lessen radio interference disturbances caused by the permanent pilot spark.

66. Moreau, A.

Argon shielded arc welding. REVUE DE LA SOUDURE - LASTIJDSCRIFT, v. 16, p. 265-275, April 1960. (In French)

Arc voltage is given as a function of amperage. Melting velocities are given for individual voltages and amperages.

67. Motoki, M, and Yamazoe, S.

Radio noise caused by the high-frequency arc welding machine. DOSHISHA ENGNG REV., v. 8, n. 1, p. 12-18, May 1957. (In Japanese)

Intense interfering radiations and voltages are produced during inert-gas arc welding. The radiation field intensity is almost inversely proportional to the $(\text{distance})^2$

from the noise source and the large interfering terminal voltage generated in the distribution lines is only slightly reduced by the use of capacitors. Measurements show that the noise is mostly produced by parts of the lead wires connecting the welding machine to the workpiece. It is suggested that the lead wires be screened.

68. Muller, A., et al

Characteristics of inert-gas shielded metal arcs

WELDING J. v. 30, p. 717-727, 1951.

The author shows the relationship between current, voltage and arc length. When a high current density is used with the Mig process, the following characteristics are observed: a large positive slope of the volt ampere characteristic, arc column stiffness and a sudden transition in drop size with the increase in wire feed speed.

69. Needham, J. C. and Hull, W. G.

Self-adjusting welding arcs.

BRIT. WELD. J., 1, 71-7, Feb 1954.

The control of arc length in "self-adjusting" arcs is considered with respect to changes in the electrode-feed rate, the current setting and the open-circuit voltage. Self-adjustment is pronounced if the open-circuit voltage is only a few volts above the arc voltage. The pre-setting of welding conditions is then greatly simplified, because the arc current automatically rises until it consumes the electrode as fast as it is fed. In addition, burn-back troubles can be eliminated. The arc is stable and its voltage is controlled by the power circuit and is constant for a wide range of electrode-feed rates. Methods of estimating the degree of self-adjustment are presented.

70. Needham, J. C. and Orton, L. H.

A. C. argon arc welding at less than 50 V r.m.s. open circuit. INSTITUTE OF WELDING, TRANSACTIONS, v. 15, p. 161-165, Dec 1952.

Open circuit voltage is reduced with the surge injector unit described.

71. Needham, J. C. and Smith, A. A.

Arc and bead characteristics for pure aluminum for range of wire feed rates (self-adjusting arc) at constant voltage in argon. BRIT. ELEC & ALLIED INDUSTRIES. Tech. Report Z/T112 1957, 15p, 10 supp plates; see also BRIT WELDING J. v. 5, n. 2, p. 66-76, Feb 1958.

Carefully controlled weld tests were made over a large range of wire feed rates at a constant arc voltage. The significance of metallurgical and electrical features is discussed in relation to arc and bead characteristics. The range for satisfactory welding is limited and the existence of sub-threshold and defective regions outside this range is established.

72. Needham, J. C., et al

Metal transfer in inert-gas shielded-arc welding. BRIT. WELD. J., v. 7, n. 2, p. 101-14, Feb 1960.

It is postulated that high-velocity plasma jets in the welding arc are responsible for metal transfer. The proposed mechanism is that the plasma jet exerts a force on the globule as it forms on the end of the electrode wire. When this force exceeds the restraining force of surface tension the globule begins to pull away from the electrode. When the globule becomes detached from the electrode it accelerates freely under the action of the jet to a terminal velocity determined by the force on the globule and the distance over which this force acts. Experimental evidence was obtained from a high-speed cine-photography examination of aluminum transfer.

73. Needham, J. C., et al

Self adjusting arc - improved power sources. WELDING RESEARCH (BRIT. WELDING RESEARCH ASSN.) v. 7, n. 4, p. 100r-2r, Oct 1953.

74. Novotny, Jan

Aerospace Technical Intelligence Center

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ARGON SHIELDED ARC WELDING (ZVARANIE OCHRONE ARGONU) 1 Nov 60, 15p. (Trans. no. MCL-475 from Zvaranie 9:276-282, 1959)

The development of argon-shielded arc welding in Czechoslovakia is discussed. The principal use of this method is for obtaining welds of good quality in Al and its alloys. Both consumable electrodes and non-consumable tungsten electrodes are employed, but the non-consumable electrode seems to be preferred. Argon-shielded arc welding equipment is manufactured in Czechoslovakia in 4 sizes for industrial applications as well as an experimental unit. Semiautomatic welding is still in developmental stages.

75. Orton, L. H., and Needham, J. C.

A. C. argonarc process for welding aluminum - oscillographic analysis of effects of welding transformer open circuit voltage on arc re-ignition. BRIT ELEC. & ALLIED INDUSTRIES RESEARCH ASSN. Tech. Report Z/T82 1952, 23p. illus. diagrs. tables, 5s; see also WELDING & METAL FABRICATION v. 20, n. 12 p. 451-4, Dec 1952.

An oscillographic analysis of electrical phenomena in the a-c argonarc process is presented. Arc re-ignition phenomena of considerable practical significance are revealed.

76. Orton, L. H., and Needham, J. C.
Argon arc welding of aluminum and its alloys.
electrical considerations. BRITISH
ELECTRICAL RESEARCH ASSOCIATION.
Report no. Z/T104, 17p. 1955.

Discusses electrical characteristics of the arc and the power circuit.

77. Orton, L. H., and Needham, J. C.
Some electrical aspects of inert-gas
shielded-arc welding. BRIT. WELDING
J., v. 2, p. 419-426, Oct 1955.

Electrical requirements are given for the arc, circuit and electrode. Examples are given for tungsten arc and consumable electrode processes.

78. Ozawa, M.
Analysis of electrode phenomena of steady
tungsten arc. BULL. ELECTROTECH. LAB.
v. 23, n. 1, p. 27-34, Jan 1959. (In Japanese)

Electrode phenomena in the tungsten arc were analysed from the point of view of consumption characteristics of the anode and cathode. The tip temperature of the electrode was determined by application of the theory of heat conduction and evaporation on the surface. In the steady state, it is possible that the sum of the radiation energy and the energy stored in the electrode becomes larger than the evaporation energy. Temperature of the anode and cathode spots differs with arc current and is calculated to be 4600-5050° K in the range of 1.3 to 145A. The anode fall is calculated to be 0.41 - 3.5 V in the range 1.3-70 A and the cathode fall is 9.1-13.2 V in the range 3.3-145 A.

79. Phelps, Donald E. and Dunec, R. H.
Ordnance Tank-Automotive Command,
Detroit, Mich. DEVELOPMENT OF WELDING
TECHNIQUES FOR ALUMINUM CORNER JOINTS.
Final Report. 1v. incl. illus. (Rept. no. 4116)
(Proj. no. TW-414) 28 Feb 61.

Notice: All requests require approval of Diamond Ordnance Fuze Labs., Wash. 25, D. C. Attn: ORDTL 06.33.

80. Phillips, A. L., Ed.
Gas shielded arc welding processes - Gas
tungsten-arc, gas metal-arc welding and gas-
tungsten-arc cutting. AMERICAN WELDING
SOCIETY, New York, 76p. 1960.

81. Puschner, M.
Role of argon in physical and metallurgical
processes during arc welding. METALL,
v. 10, n. 9-10, p. 423-427, 1956. (In German)

Arc phenomena are discussed.

82. Pukhov, G. A.
Aerospace Technical Intelligence Center,
Wright-Patterson Air Force Base, Ohio.
WELDING OF LIGHT METALS AND THEIR
ALLOYS (SELECTED PAGES FROM CHAPTER IV).
30 Jan 61, 11p. incl. illus. tables (Trans. no.

MCL-812 of Svarka Legkikh Metallov i Ikh Splavov, Moscow: pp. 82-83, 131-135, 142-145, 1959)

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Arc welding of light metals and alloys, by G. A. Pukhov

Automatic arc welding in Argon envelope, by G. A. Pukhov

Flux and its use in welding, by G. A. Pukhov.

83. Republic Aviation Corp. TUNGSTEN INERT GAS SHIELDED ARC WELDING. Manufacturing Research Report no. MRP 58-73, Final Report part V. 31 Oct 1959, 167p. AMC-TR No. 59-7-769.

Reports procedures and process.

84. Rollason, E. C.
The electric arc in welding. Introductory survey. BRIT. WELD. J., v. 7, n. 2, 71-2, Feb 1960.

85. Salter, G. R., and Milner, D. R.
Gas absorption from arc atmospheres. BRIT. WELD. J. v. 7, n. 2, 89-100, Feb 1960,

The absorption of oxygen from an argon–oxygen arc atmosphere by titanium was determined by hardness surveys. The effect of welding variables was investigated. It is concluded that the process controlling the reaction is the rate of diffusion of oxygen across a stagnant gaseous boundary layer adjacent the metal surface, and that this takes place over an "active area" in the high-temperature region of the arc. The magnitude of the high-temperature "active area" is determined by the current arc length.

86. Shaffran, S. S.

Air Reduction Co., Inc., Murray Hill, N. J.

INERT-GAS METAL-ARC WELDING OF FOUR-INCH-THICK HY-80 STEEL PLATE, Final rept. 30 June - 31 Dec 58, 62p. incl. illus. tables, 10 refs. (Contract NObs-72087)

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87. Shajenko, Petro

Detroit Arsenal, Center Line, Mich.

INVESTIGATION OF ARC BLOW IN THE WELDING OF ARMAMENT MATERIALS. 18 Dec 58, 24p. incl. illus. (Proj. no. 551-5; Rept. no. 4271 (Final))

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Conclusions: Although there are many factors which may produce arc blow, the major factor is residual magnetism in the welding plates. This magnetism is usually in the plates when received for fabrication and assembly into a final product. Residual magnetism in the plates can be increased during handling, fabricating and assembly, therefore, it must generally be eliminated during the welding operation to be fully effective in preventing arc blow. The most severe cases of arc blow were eliminated through the use of a controllable d-c electromagnet or rotating-welding-rod gun developed in this project. (Author)

88. Shchitova, V. M. and Lebedev, A. M.

Self regulation of a three phase arc in welding with a fusible electrode. ELEKTRICHESTVO, n. 7, p. 51-57, 1956. (In Russian)

An investigation of static and dynamic characteristics showed that a three phase system with a self-regulating arc has disadvantages compared with a single phase system in that regulation based on arc length variation is unsatisfactory. Variations of arc length or bath level result in variations of all three arc voltages and of the current flow. The solution to the problem lies in the use of a forced regulation system.

89. Sherman, C. and Yos, J. M.

Scaling laws for electric arcs subject to forced convection. J. APPL. PHYS., v. 32, n. 4, p. 744, 1961.

Effects included in this analysis are those of viscous compressible flow, conductive, convective, and radiative heat transfer, and ohmic heat dissipation.

90. Sibley, C. R.

Argon-shielded alternating current metal-arc welding. WELDING J., v. 40, n. 11, p. 481s-488s. 1961.

Proper electron emission characteristics must be provided to prevent the loss of a conductive path as the welding current passes through zero in order to obtain a stable spatter-free a.c. arc in argon with conventional low-open-circuit voltage welding transformers. Rb and Ce compounds, when coated uniformly on bare-welding wire, provide sufficient electron emission to make the a.c. arc completely stable without the need for high open-circuit-voltage or superimposed high-frequency sparks.

91. Siunov, N. S., and Urmanov, R. N.

Fundamental relationships in the three-phase welding arc. ELEKTRICHESTVO, no. 2, p. 18-21, 1955. (In Russian)

The main advantage of 3-phase arc welding is the possibility of regulating the distribution of thermal energy between the individual arcs and hence the depth of fusion of the work to be welded as well as the quantity of metal to be welded on.

92. Skinner, G. M., and Yenni, D. M.

Inert Gas-Shielded Welding Arc Behavior

and Metal Transfer Characteristics.

AIEE TRANS. II, Applic. and Industr.,

v. 75, No. 23, p. 28-32 (1956)

Relationships were observed between current transients and arc physical behavior. Arcs shielded with argon or a mixture of argon + 5% oxygen were more stable and operated with less spatter than arcs in helium or helium + 5% oxygen. Although addition of oxygen to argon was desirable, addition of oxygen to helium did not improve arc behavior or metal transfer.

93. Skolnik, M., and Jones, T. B.

Characteristics of the high current tungsten arc

in argon, helium, and their mixtures.

J. APPL. PHYS. v. 23, n. 6, p. 643-652, 1952.

Results of an experimental study of the properties of a high current d.c. arc at atmospheric pressure are presented. Measurements of voltage current and voltage electrode separation characteristics were made.

94. Skolnik, M., and Jones, T. B.

High-current tungsten arc in argon, helium

and their mixtures. WELDING J.

v. 32, p. 55s-64s, Jan 1953.

Results of a preliminary exploration study are presented. The arc was found to be stable when the system was free from oxide impurities.

95. Smith, A. A., and Houldcroft, P. T.
High-current, inert-gas metal-arc welding of aluminum. BRIT. WELDING J. v. 5, n. 9 p. 421-6, Sept 1958.

Details of tests to determine the effects of torch and joint angle, wire composition and diameter, voltage, and gas coverage on puckering are presented.

96. Smith, J. L. and Boyle, W. S.
Fundamental processes of the short arc with applications to contact erosion and percussion welding. BELL SYST. TECH. J., v. 38, n. 2, p. 537-52, March 1959.

A short arc develops instability when certain critical conditions of power input to the arc are not satisfied. In this unstable condition the arc is momentarily extinguished and a molten filament of metal is drawn between the electrodes which may permanently bridge them. Semi-empirical expressions are given, which predict at what time in the life of an arc it becomes unstable. The analysis is useful in determining the optimum current waveform for percussion welding, where a stable arc is desirable.

97. Tret'yakov, F. E., et al
Tantalum argon-arc welding of tantalum. WELDING PRODUCTION (translation of Svarochnoe Proizvodstvo), p. 12-20, Aug 1959.

Tantalum welds well with non-consumable electrodes in argon using d-c straight polarity.

98. Tuthill, R. W.

Arc characteristics for consumable-electrode gas-shielded welding. WELDING J. v. 33, p. 128-132, Feb 1954.

The investigation was made to establish volt-ampere curves for different metals.

99. Vegner, O. G.

Improvement of the stability of the a.c. welding arc. ELEKTRICHESTVO, n. 5, p. 67-70, 1958. (In Russian)

A saturable, premagnetized reactor is described which is inserted into the circuit to speed-up the current reversal of the sinusoidal current which will in turn, improve arc stability.

100. Verchenko, V. R.

The static arc characteristics in gas shielded welding with consumable electrodes. AVTOMATICHESKAYA SVARKA, v. 65, p. 74-77, Aug, 1958. (In Russian)

Arcs for consumable electrode gas shielded welding have rising static volt-ampere characteristics. The slope of these characteristics depends on the gas used, arc length, and the diameter and properties of the electrode wire.

101. Waller, M.

Developments in power sources for inert gas tungsten arc welding. BRIT. WELDING J. v. 5, n. 9, p. 407-415, 1958.

An a.c. and a d.c. power source are described. Modifications for the d.c. machine are presented.

102. Weare, N. E., Monroe, R. E., and Martin, D. C.

Inert-gas shielded consumable-electrode welding of molybdenum. WELDING J. v. 37, n. 3, p. 117s-24s, March 1958.

Studies of arc stability and metal transfer in molybdenum arcs were made.

103. Welch, A. U.

New power sources for metal-arc-gas-shielded welding. WELDING J. v. 36, n. 1, p. 36-40, Jan 1957.

D-C rectifier welders designed specifically for gas shielded consumable electrode arc welding and high current density submerged arc welding are discussed. Deficencies of unregulated welders can be overcome by including proper controls.

104. Wells, A. A.

A momentum principle for arc force. BRIT. WELDING J., v. 9, n. 4, p. 227-231, 1962.

The author examines two arc phenomena; electromagnetic pinch, and gas entrainment in the arc to form a plasma jet. Arc force is readily measured and calculated.

105. Wilkinson, J. B., and Milner, D. R.

Heat transfer from arcs. BRIT. WELD. J. V. 7, n. 2, 115-28, Feb 1960.

Energy distribution as determined for arcs between a non-consumable tungsten cathode and a water-cooled copper anode in atmospheres of A, N, He and H. In general, 80-90% of the energy expended in an arc of this type was found to go to the anode, with the remainder divided between cathode heating and heat carried away by the gas, which leaves the arc region at temperatures of the order of 1000-6000°K.

106. Willecke, G. K.
Welding arc requirements and power source design parameters. In Eighth Annual Midwest Welding Conference, Jan 31, 1962. Chicago Armour Research Foundation, 1962, 14p.

107. Willhelm, A. Clyde
Southern Research Inst., Birmingham, Ala.
INVESTIGATION OF THE FEASIBILITY OF WELDING MOLYBDENUM SHEET WITH A DEOXIDIZING AND GRAIN REFINING FLUX.
Interim rept. no. 1, 30 Dec 60-30 Mar 61, 28 Apr 61, 10p. incl. illus. tables (Rept. no. 4916-1257-I) (Contract NOw 61-3066-d)
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108. Wooding, W. H.
The inert-gas-shielded metal-arc welding process. WELDING J. v. 32, n. 4, p. 299-312; n. 5, p. 407-423, 1953.

109. Zimmerman, P. M.
Toroid measures spot weld current. ELECTRONICS, v. 30, n. 12, p. 133, Dec 1957.

Voltage developed by a toroidal pick-up coil around the welding electrode is converted to a steady-state meter reading by an a.c. vacuum tube-voltmeter circuit. Accuracy is within 3% of full-scale meter deflection for weld times of 3 to 30 cycles. The meter reading is held several minutes before the needle returns to zero.